Electronic Systems Branch Presentation: Ares I-X Development Flight Instrumentation (DFI)







Outline



- ◆ Test Flight Overview
- ◆ SE & I DFI Team Responsibilities
- Hardware Architecture
- Measurement Classifications
- Sensor/Measurement Totals
- Graphical Tools
- Sensor Types
- DFI Processing
- Contamination Covers
- Imagery
 - Including Recorded Video
- DFI As-Built Measurement List

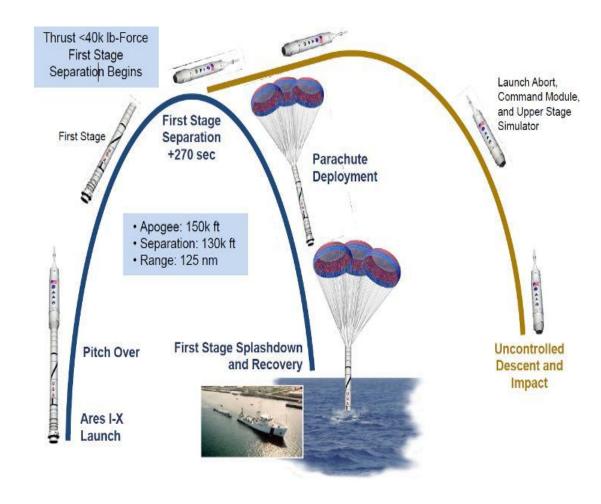


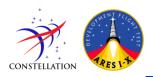
Ares I-X Test Flight Profile



- •The Ares I-X Test Flight occurred on October 28th, 2009 at 11:30 am EST
- The Ares I-X Test Flight was a suborbital ascent development flight to assist in demonstrating and collecting invaluable data for Ares I designs including
 - Vehicle Control
 - Stage Separation
 - Aerodynamics
 - Loads and Re-entry Dynamics
 - •Parachute Performance needed for First Stage Recovery
- •The Flight Test profile was established as a means of closely approximating the flight conditions that would be realized by the Ares I Rocket through Mach 4.7 and at an altitude of approximately 130,000 feet

Ares 1-X Launch [HD].mp4





SE&I DFI Team Roles & Responsibilities

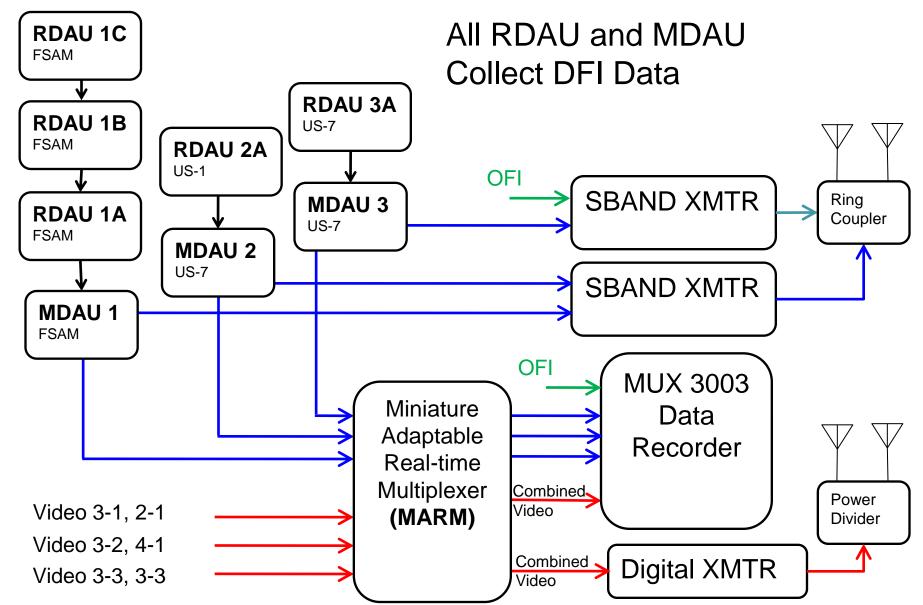


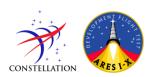
- ◆ The System Engineering & Integration (SE&I) DFI Team was responsible for collecting/deriving measurement requirements from both the Ares I and Ares I-X Disciplines Leads and Elements to meet Ares I-X Flight Test Objectives
 - AI1-SYS-DFI (version 3.10)
- The Team also provided oversight during Design, Implementation, Integration, Testing, and Verification
 - Some Key Activities/Duties include the following:
 - DFI Working Group Meetings
 - Assisted with the development of the Operational Test Requirements and DFI Processing
 - Developed Launch Commit Criteria (LCC) for Mandatory DFI
 - Removable Contamination Covers
 - LaRC Telemetry Receiver Upgrades in support of 1-X Launch
 - DXCB Board Member
 - System Integration Laboratory (SIL) support
 - Channelization and System Integration Testing Support
 - Verification Requirement Document (VRD)
 - Provide As-Built Document



DFI Architecture

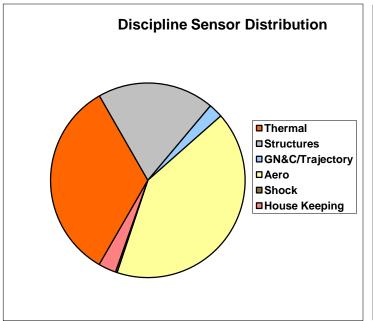


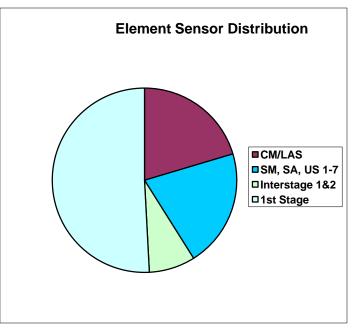




Sensor Totals

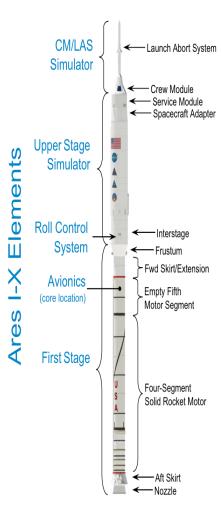






	Number of			
Discipline	Sensors	% of Total		
Thermal	239	33%		
Structures	139	19%		
GN&C/Trajectory	17	2%		
Aero	298	42%		
Shock	2	0%		
House Keeping	21	3%		
Total	716	100%		

Element	Number of Sensors	% of Total		
CM/LAS	146	20%		
SM, SA, US 1-7	148	21%		
Interstage 1&2	58	8%		
1st Stage	364	51%		
Total	716	100%		



Note: Sensor Totals are based upon those Sensors sampled by the Data System. These Totals do not include those Measurements tracked by Al1-SYS-DFI v3.10, but not sampled by the Data System



Sensor Types



Thermal

 Thermocouples, Gas Temp Probes, Radiometers, Calorimeters, Differential Pressure, Static Pressure





Structures

 Accelerometers, Microphones, Strain Gauges, Load Cells, Shock



 5-Hole Probe, Air Data Vanes, TAT, INU

Aero

 Low Freq Unsteady Pressure, High Freq Unsteady Pressure









Measurement Totals

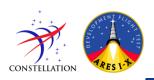


Element	Number of Measurements
CM/LAS	160
SM, SA, US 1-7	196
Interstage	89
1st Stage	454
Total	899

Discipline	Number of Measurements	
Thermal	286	
Structures	187	
GN&C/Trajectory	46	
Aero	298	
House Keeping	82	
Total	899	

Pyro Shock		
	Totals	
Description	Sensor Count	
Frustum Sep. Pyro Shock	0	
Forward Skirt Sep. Pyro Shock	2	
Shock Totals	2	

Note: Sensor Totals are based upon those Sensors sampled by the Data System. These Totals do not include those Measurements tracked by Al1-SYS-DFI v3.10, but not sampled by the Data System



Measurement Classifications



DFI Measurement Classification Requirements

DFI Criticality Definitions

<u>Mandatory:</u>DFI Measurements Required to meet Primary Objective; if these DFI Measurement fail, we cannot meet that Primary Objective

<u>Silver Bullet:</u>DFI Measurements that not only support Ares I-X Objectives, but also significantly add to the benefit of this test flight relative to the Data needs of Constellation/Ares I

<u>Secondary:</u>DFI Measurements to meet Secondary Flight Test Objectives and/or supplement Primary Flight Test Objectives

DFI Measurement Categories						
Category	Redundancy	LCC	Ambient Check Day of Launch	Replacement Strategy	Confidence Testing Required	Operational Requirements ³
Mandatory	Yes	Yes	Yes	Replace	Yes ¹	100% Functional on DOL
Silver Bullet	No	No	Yes	Replace if no Launch Impact	Yes ²	100% Functional at time of Rollout
Secondary	No	No	No	Replace if no Launch Impact	No	100% Functional at Pre-Stack

Note 1: Confidence Testing of Mandatory Sensors when feasible (i.e. 5-Hole Probe, OPT, Air Data Vanes)

Note 2: Confidence Testing of 113 (22 Unsteady-HF and 91 Unsteady-LF) Aero Discipline Pressure Measurements

Note 3: Operational Requirements may affect sensor spare utilization

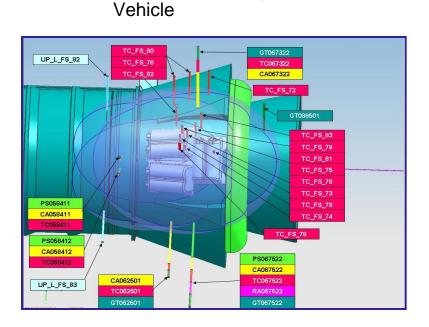


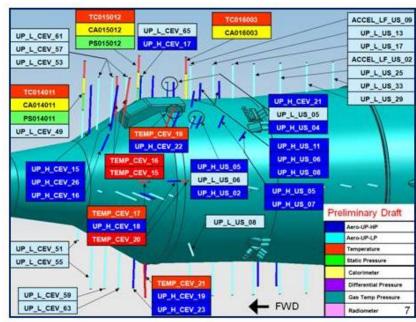
LaRC Geometry Laboratory Model

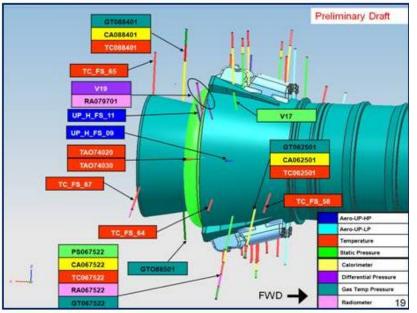


- SE&I DFI Team worked with the folks in the Geolab to generate an Ares I-X OML DFI Overlay
 - Initially used as a tool for Measurement Requesters
 Sensor Distribution
 - Also used by the DFI Team and Avionics in an effort to determine DFI transducers that may be affected by elevated vibro-acoustics in certain protuberance regions

of the Ares I-X Flight Test









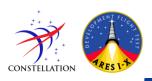
DFI Processing/Testing



- SE&I DFI Team worked with Avionics and Ground Ops to develop Operation Test Requirements (OTR)s for DFI Channelization
 - Verify copper path from Sensor to Data System
 - Verifies sensor is connected to the appropriate channel of the Data System
 - Verifies channel is in correct location in output matrix (PCM Format)

Response Verification/Confidence Testing

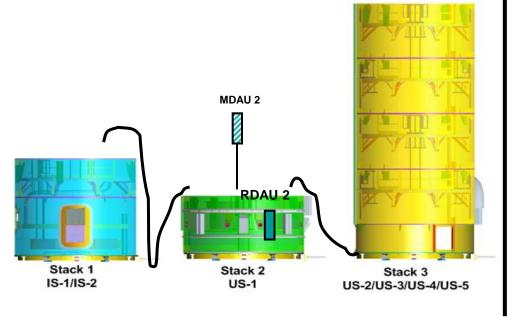
- Worked with NESC and Ares I to provide additional testing for those measurements from the Five Primary Aerosciences Technical areas that were mapped to specific Ares I-X vehicle components (RoCS, Frustum/Fwd Skirt, Aft Skirt, CM/SM Interface, Instrument Unit). A "Silver Bullet" list was generated to meet the specific technical needs of the community in these specific areas of interest
- Confidence Testing was performed on ~ 113 Aero Discipline Pressure Sensors from Silver Bullet List
- Confidence Testing was performed on Mandatory Measurements whenever feasible

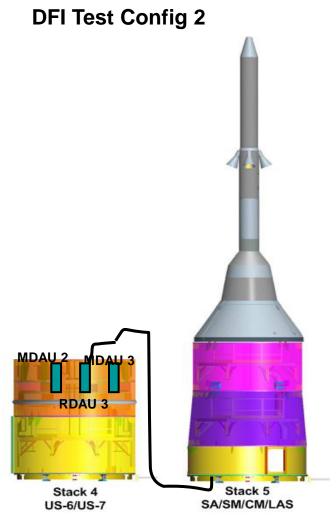


DFI Channelization Test Configurations



DFI Test Config 1 test harness

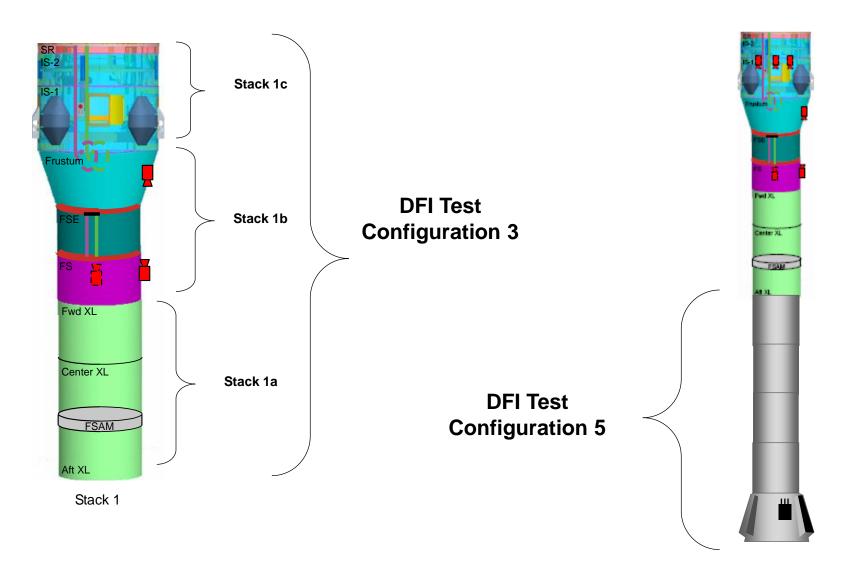






DFI Channelization Test Configurations



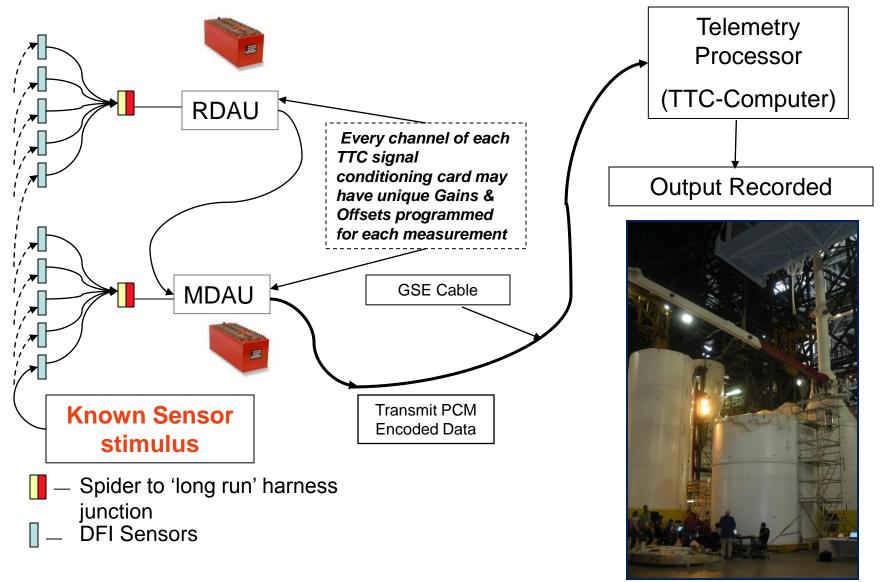


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Response Verification Performed During End-To-End Channelization



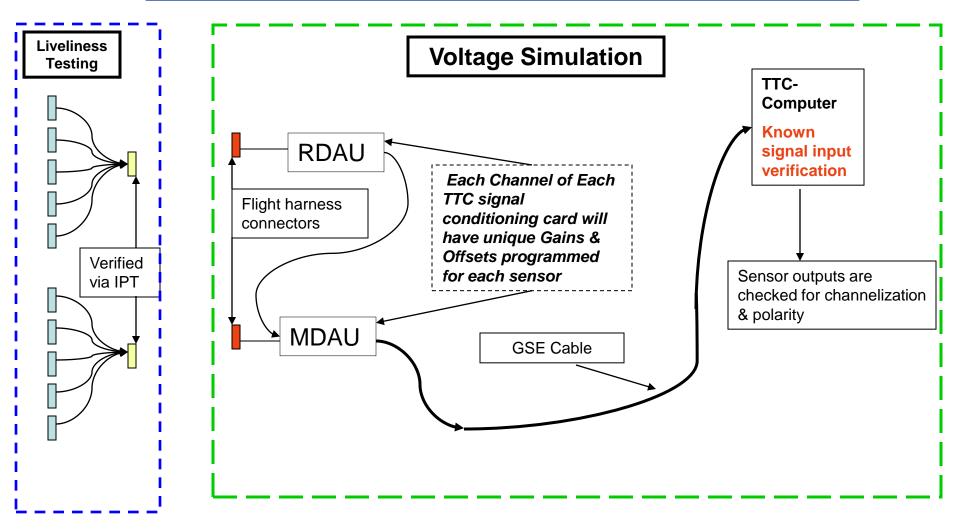


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DFI Sensor Channelization Method for Sensors that cannot be Stimulated





- □ − DFI Sensors
- Spider/harness connectors



Contamination Covers



- ◆ The SE&I DFI Team worked with several of the KSC Ground Ops folks to develop Removable Contamination Covers
- Why Covers are needed:
 - Concerned with the external environments and their effect on the DFI sensors. Rain, mosquitoes, bird guano (droppings), etc.
 - Examination of the DFI sensor list suggests that several were prone to having data compromised when exposed to a variety of natural environments
 - 5-Hole Probe, Total Air Temperature (TAT) Sensor, and fwd facing Cameras
 - After numerous meetings with both the DFI working Group and the Launch & Flight Integration Deputy Manager at KSC, work was initiated at KSC on the design of removable covers for the 5-Hole Probe and TAT

5HP Cover



Tip of cover sewn with a V configuration as a means to reduce the possibility of a puncture during pull

TAT Cover

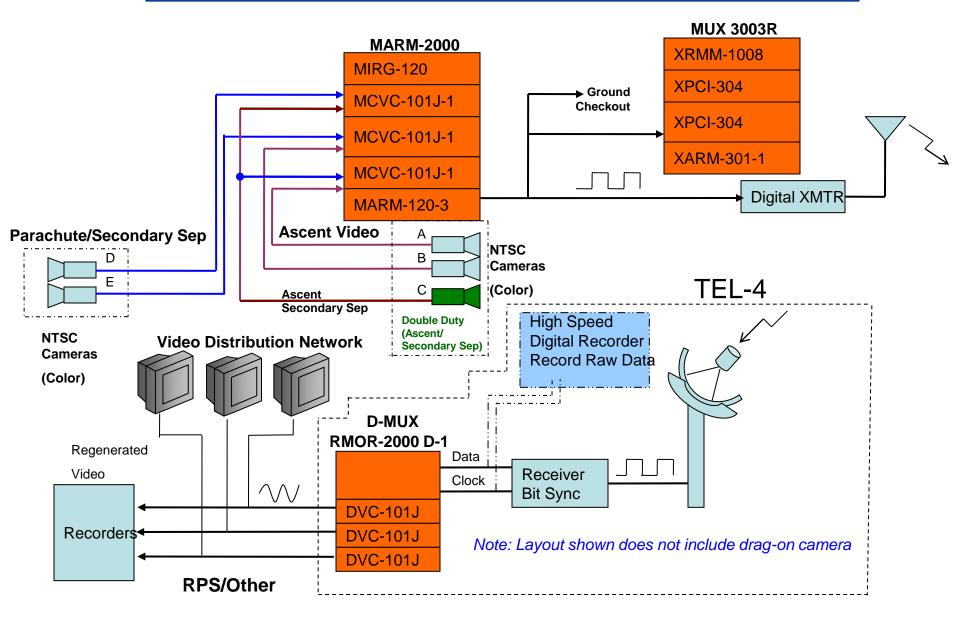


Additional Velcro ring and rubber added below cover to prevent premature pull and clocking change



Ares I-X Video: As-Flown System Architecture







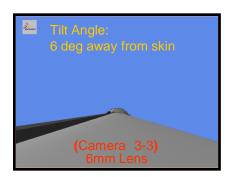
I-X On-Board Imagery



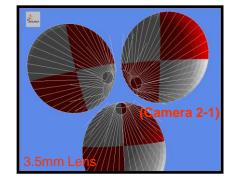
Ascent

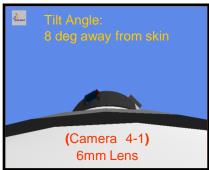


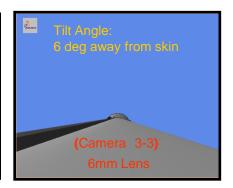




Post Separation



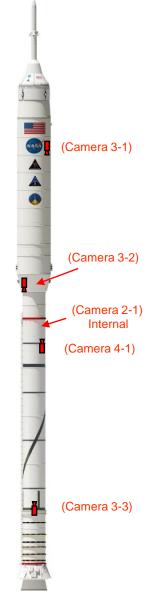




- ◆ ch1 Camera 3 1 and Camera2 1.mov
- ◆ ch3_Camera3_3.mov

Ecliptic Rocket Cam







Payload Imagery



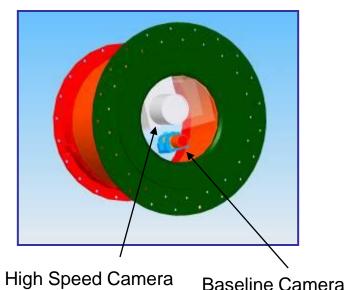
- MSFC provided a High-Speed Digital Camera on the Ares I-X Flight Test for Parachute Deployment
 - Funding leveraged from 1st
 Stage Mainline Program.
 - System will be self contained
 - Power, Data, Triggers etc is not required from Ares I-X Avionics
- High Speed Digital Camera was flown in parallel with Ares I-X Baselined Camera (2-1)
 - High Speed Camera is a Payload was not dependent on Ares I-X Avionics
- Camera provided invaluable data used to determine Parachute failures

Ares I-X On-board High Speed

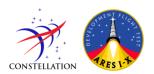
Main Parachute

Footage.mp4





Bulkhead Camera
Housing in Fwd
Dome



Post Flight Activities



Post Flight Data Assessment

MSFC TIM

DFI As-Built Document

- Actual Resolutions, Sample Rates, Locations, Sensor Serial Numbers (so that the appropriate sensor calibration can be referenced to a particular Measurement), DFI Channelization Testing Anomalies and Directives, and Post Flight Assessment Notes
- Several new additions:
 - Accelerometer Polarity, Teletronics Technology Corporation (TTC) Data
 Acquisition Channel Assignments, DFI System Timing Description, and a Waiver
 Log that contains all known Waivers relating to the DFI System

Lessons Learned

- SE&I
- Avionics

Engineering Unit Coefficient Conversions

- Silver Bullet and Secondary Measurements
- Support of Ares I USS DFI Team
- Ares II-X/FT2 DFI Trade Study
- Orion I and Orion II